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SURVEY OF FLUE GAS DESULFURIZATION SYSTEMS. REID GARDNER STATION, NEVADA POWER COMPANY

Richard W. Gerstle, et al

PEDCo-Environmental Specialists, Incorporated

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SURVEY OF FLUE GAS DESULFURIZATION SYSTEMS

REID GARDNER STATION, NEVADA POWER CO.

by

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Research Triangle Park, North Carolina 27711

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October 1975

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16. ABSTRACT

The report gives results of a survey of flue gas desulfurization (FGD) systems to control SO2 and particulate emissions from two existing 125 MW generating units at Nevada Power Company's Reid Gardner Station. Two additional 125 MW units, originally planned for installation in 1976 and 1977, are to incorporate similar FGD equipment. (Installation of the second new unit has been postponed indefinitely.) The FGD systems utilize a sodium carbonate scrubbing process. The systems, placed in operation in April 1974, did not meet SO2 and particulate performance guarantees during their first year of operation. Each system utilizes twin parallel venturis followed by an absorber tower. As of August 1, 1975, System 1 had operated for 3814 hours and System 2, for 2947 hours. Potential availabilities for the systems seem to be near 100 percent, but the plant has not had access to an adequate supply of trona, a sodium carbonate ore that constitutes the scrubbing medium. Alternate sodium carbonate sources were secured recently.

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Mr. Wade H. Ponder, former EPA Project Officer, had primary responsibility within EPA for this project report. Information and data on the plant operation were supplied by Mr. David G. Barneby, Nevada Power Company, by Mr. R. S. Sommer, Combustion Equipment Associates, Inc., and Mr. D. C. Philp, Bechtel Corporation during and subsequent to the plant survey visit.

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SUMMARY

Flue gas desulfurization (FGD) systems have been designed and installed to control sulfur dioxide and particulate emissions from two existing 125 MW generating units at the Reid Gardner Station of Nevada Power Company (NPC). Two additional 125 MW units, originally planned for installation in 1976 and 1977, are to incorporate similar FGD equipment. The installation of the second new unit has been indefinitely postponed.

The FGD systems utilize a sodium carbonate scrubbing process developed, designed and supplied by Combustion Equipment Associates, Inc. (CEA) and its joint venture partner, Arthur D. Little, Inc. (ADL). Bechtel Corp. performed the architectural/engineering work for the systems. The systems were placed in operation in April 1974, and have not met SO_2 and particulate performance guarantees during the first year of operation. Each system utilizes twin parallel venturis followed by an absorber tower. As of August 1, 1975, System 1 had operated for 3814 hours and System 2 had operated for 2947 hours. Potential availabilities for the systems seem to be near 100 percent, but the plant has not had access to an adequate supply of trona, a sodium carbonate

ore that constitutes the scrubbing medium. Alternate sodium carbonate sources recently have been secured. Pertinent operational data are summarized in the following table.

SUMMARY OF FGD DATA, REID GARDNER UNITS 1 AND 2

Unit rating, MW (net)	110
Fuel	Coal
Gross heating value, BTU/lb	12,500
Ash, percent	9
Sulfur, percent	0.6
FGD process design	Combustion Equipment Associates Inc./ Arthur D. Little, Inc.
Process	Aqueous sodium carbonate scrubbing
New or retrofit	Retrofit
Start-up date	April 1974
FGD modules	One per unit
Efficiency, percent	
Particulates Scrubber and multicyclone	99+
SO_2	90+
Make-up water, gpm/MW	1.3
Disposal	Evaporation ponds
Unit cost, $/KW (net)	50

1.0 INTRODUCTION

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The Industrial Environmental Research Laboratory (formerly Control Systems Laboratory) of the U. S. Environmental Protection Agency (EPA) has initiated a study to evaluate the performance characteristics and degree of reliability of flue gas desulfurization (FGD) systems on coal-fired utility boilers in the United States. This report on the Reid Gardner Station of Nevada Power Company (NPC) is one of a series of reports on such systems. This report presents data on key process design and operating parameters, describes the major start-up and operational problems encountered at the facility and the steps taken to alleviate such problems, and identifies the total installed and annualized operating costs.

This report is based upon information obtained during a plant inspection on October 8, 1974, and on data provided by NPC and Combustion Equipment Associates, Inc. (CEA).

Section 2.0 presents pertinent data on facility design and operation. Section 3.0 describes the FGD system, and Section 4.0 analyzes FGD system performance. Appendices present details of plant and system operation and photos of the installation.

2.0 FACILITY DESCRIPTION

The Reid Gardner Station of NPC is located near Moapa, Nevada, about 50 miles northeast of Las Vegas. This is a sparsely populated, arid part of Nevada. The station has two electric power generating units, (Reid Gardner Units 1 and 2) each rated at 125 MW (gross).

Both units are identical in design and operate under base load conditions. The pulverized-coal-fired boilers were manufactured by Foster-Wheeler. Unit No. 1 was placed in service in 1965 and Unit No. 2 started operation in 1968. Utah coal is burned, having an average gross heating value of 12,500 BTU/lb and average ash and sulfur contents of 9 and 0.6 percent, respectively.

Reid Gardner Unit 3 is presently under construction with a start-up date scheduled for 1976. Its design capacity is 125 MW. Reid Gardner Unit 4 was in the planning stage but has been indefinitely postponed.

Enforcement action by Clark County in 1970 led NPC to contract with Bechtel Corporation for design and installation of an FGD system. Bids for FGD systems were solicited in 1971. CEA was the only vendor that proposed a soluble reagent (sodium carbonate) scrubbing medium, and they were

selected for the work. In early 1972, CEA/ADL designed, built and operated a 7000 to 9000 acfm pilot unit at the plant to better define operating variables using less expensive trona as a source of sodium carbonate. Two full-scale scrubbers were placed in service in April 1974. Table 2.1 summarizes pertinent data for the boilers and the atmospheric emissions.

Clark County, Nevada limits SO_2 emissions to 0.15 lb/MM BTU input. The State of Nevada limits SO_2 emissions to 0.21 lb/MM BTU input.

Table 2.1 PERTINENT DATA ON PLANT DESIGN, OPERATION AND ATMOSPHERIC EMISSIONS - REID GARDNER STATION

Boiler data	1	2
Rating generating capacity, MW (gross)[a]	125	125
Average capacity factor (1973), %	73	73
Boiler manufacturer	F-W	F-W
Year placed in service	1965	1968
Maximum coal consumption, ton/hr[b]	47.5	47.5
Maximum heat input, MM BTU/hr[b]	1187.5	1187.5
Stack height above grade, ft	200	200
Flue gas rate - maximum, acfm	473,000	473,000
Flue gas temperature, °F	350	350
Emission controls		
Particulate	Multicyclone and venturi scrubber	Multicyclone and venturi scrubber
SO_2	Venturi scrubber and absorber tower	Venturi scrubber and absorber tower
Particulate emission rate		
Allowable, lb/MM BTU	0.12	0.12
Actual, lb/MM BTU	0.055	0.55
SO_2 emission rate		
Allowable, lb/MM BTU	0.15	0.15
Actual, lb/MM BTU[c]	0.115	0.115

[a] Net without scrubber is 112 MW. With scrubber and reheat, net is 106.5 MW.

[b] Calculated value.

[c] Based on 84% removal efficiency (310 ppm inlet, 50 ppm outlet) and a 0.72 lb/MM BTU inlet concentration.

3.0 DESULFURIZATION SYSTEM

3.1 PROCESS DESCRIPTION

The sodium carbonate based FGD systems on Reid Gardner Units 1 and 2 were placed in operation in April 1974. The design of these systems was based on data gathered from the operation of an 8000 acfm pilot plant which operated at the Reid Gardner Station during 1971 and 1972.

The FGD system on each boiler consists of a single module, designed to handle 473,000 acfm of gas at 350°F. The module is made up of two parallel variable throat venturi scrubbers followed by a single-stage perforated plate washing tower. The FGD modules on both boilers share a common trona (sodium carbonate ore) storage and beneficiation system. Beneficiation consists of settling out insolubles (mainly sand) in a clarifier. Bypassing of each module is possible through the use of leaf and guillotine isolation dampers.

3.1.1 Flue Gas Flow

As shown in Figure 3.1, the hot flue gas from the boiler passes through an existing mechanical collector (multicyclone) where about 75 percent of the fly ash is removed. The flue gas is then drawn through a 3000 hp fan

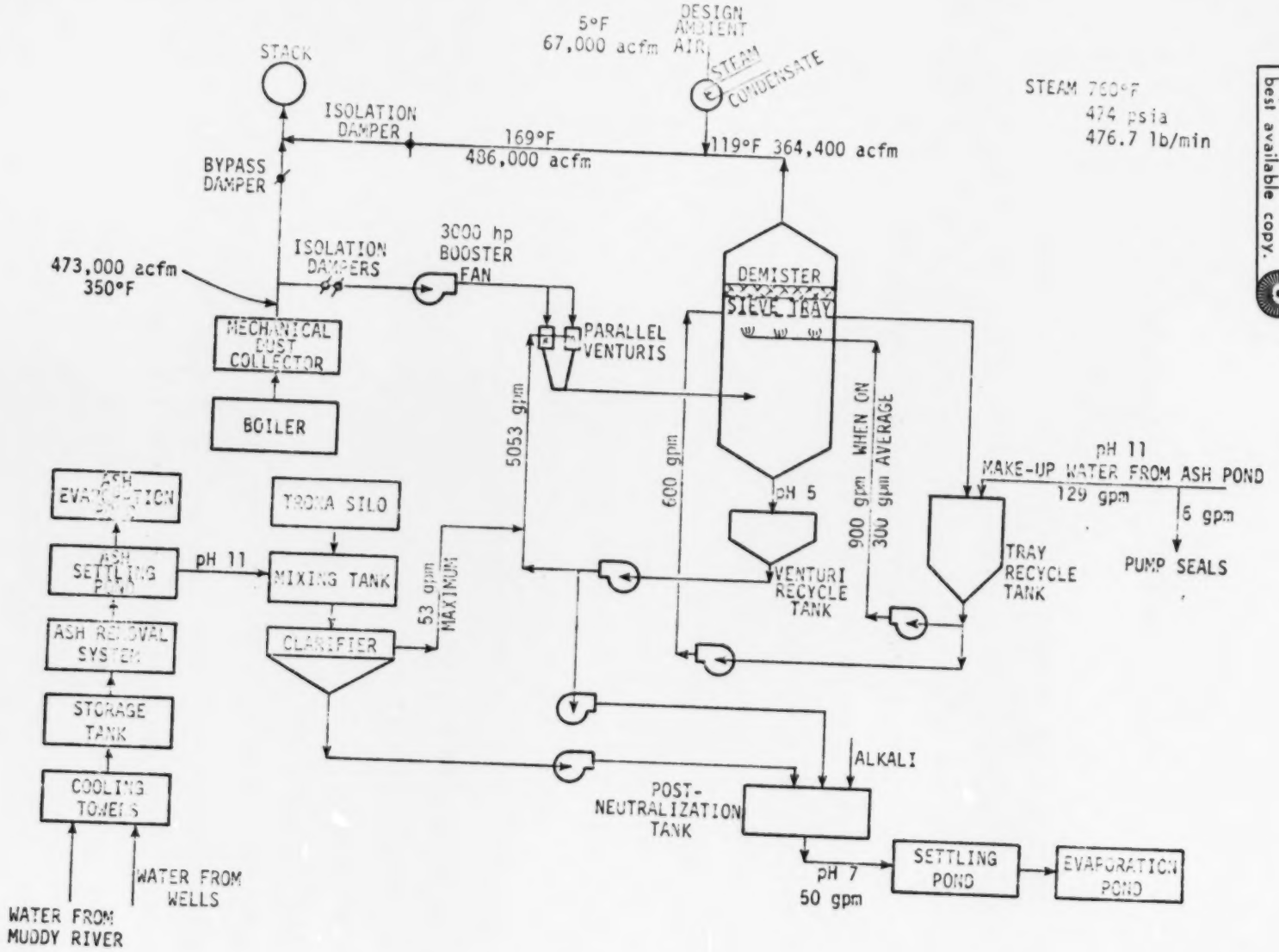

Figure 3.1 Simplified flow diagram of FGD system, Reid Gardner Station - Nevada Power Company.

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after which it splits into two streams and enters the twin throat venturi scrubber. Here the hot flue gas is quenched with circulated scrubbing liquor sprayed from tangential nozzles located on the walls of the venturi. The gas-liquid mixture then passes through the venturi throats and exits into a sump, where the reduction in velocity causes the liquor droplets to fall and separate from the gas stream. A liquid-to-gas ratio (L/G) of 10 gal./1000 acf of gas at 130°F and a pressure drop of about 15 inches of water are maintained in the venturi for efficient removal of SO_2 and particulates. The rectangular venturi throat opening is 18 inches wide by 18 feet long. The scrubbed gas at a temperature of 130°F then tangentially enters the cylindrical droplet separator tower. The centrifugal force created by the tangential flow causes the finer droplets to coalesce near the tower's wall and separate from the gas stream. The scrubbed gas rises through the tower and bubbles through 3/16 in.-diameter holes in a single sieve tray. The tray is flooded with clear water from the ash pond at a rate equivalent to 1 gpm per 1000 acfm of gas. This tray is intermittently washed with fresh water sprayed against the tray bottom. More SO_2 is absorbed in the sieve tray and the pH of the tray liquid drops from 6.2 to about 5. The cleaned gas continues up the tower and passes through a single-pass, horizontal radial vane-type mist eliminator where entrained liquid droplets are removed. The vanes are type 316L stainless steel. No demister washing is provided.

In order to give buoyancy to the gas and to prevent condensation on the duct and stack walls, the gas is re-heated by direct mixing with hot air. This hot air is generated by drawing ambient air through a separate fan and indirectly heating it in a finned tube heat exchanger using steam. The combined gas stream enters a 200-foot tall stack and is discharged to the atmosphere.

3.1.2 Liquor Flow

The FGD system water is supplied from the ash settling pond (see Figure 3.1). This water is originally supplied to the cooling towers from wells and from the Muddy River. Trona, a low grad ore containing 60 percent sodium carbonate, 20 percent sodium chloride, 10 percent insolubles, 10 percent sulfates and inert dissolved solids, is normally used as the SO_2 scrubbing agent. Trona is shipped to the Reid Gardner Station in powdered form. The trona is transferred pneumatically to a silo having a 3-day storage capacity. From there it is conveyed to a slurry tank and mixed with water from the ash ponds to dissolve the sodium carbonate. The slurry, containing such impurities as sand and sodium chloride, is mixed with a portion of the supply water and is pumped to a clarifier where insoluble impurities settle out. The clarified sodium carbonate liquor is injected into the venturi recirculation loop. The remainder of the make-up water (pH 11) is injected into the absorber circuit via the tray recycle tank. Blowdown from the venturi recycle tank is mixed with the alkaline

clarifier underflow stream and adjusted to pH 7 in the post-neutralization tank. The spent liquor from the post-neutralization tank amounts to about one percent of the recycle liquor flow through the venturi and absorber. The spent liquor is pumped to a 6-acre ash settling pond, and the overflow from this pond flows to a 45-acre evaporation pond. No liquor is recycled to the modules from these ponds. This method is appropriate for the disposal of spent liquor in Nevada because of the low relative humidity in that area. All make-up water is supplied from the ash settling pond.

3.2 DESIGN PARAMETERS

Design details of this scrubbing system are proprietary to CEA. The system chemistry is based on the following reactions:

$$Na_2CO_3 + SO_2 \rightarrow Na_2SO_3 + CO_2$$

$$Na_2SO_3 + SO_2 + H_2O \rightarrow 2NaHSO_3$$

The first reaction predominates so that there is little $NaHSO_3$ in the absorber effluent. Alkaline constituents in the make-up water entering the sieve tray also aid the absorption of SO_2. A pH of approximately 6.2 is maintained in the absorber inlet liquor. It is reported that 0.8 to 0.9 moles of Na_2CO_3 are used per mole of SO_2 removed.

Make-up solution is fed at a rate of about 50 gpm into the venturi recirculation loop. Within this loop, about 5000 gpm of liquor (L/G=10), is injected into the two venturi scrubbers where fly ash and some SO_2 is captured. A pressure

drop of about 15 inches of water occurs across the venturi at a throat velocity of approximately 165 ft/sec. The liquor is partially separated from the flue gas in the lower portion of the 30-foot diameter perforated plate tower where the gas velocity is reduced to approximately 11 ft/sec. Liquor from the bottom of this tower flows to a recirculation tank. The underflow from this tank is mixed with fresh solution and recycled to the venturi scrubbers. Underflow from the recirculation tank which amounts to approximately 50 gpm (1%) is bled off to the ash settling pond.

Flue gas passing upward through the perforated plate at a temperature of about 130°F is contacted with liquor which is recirculated at a rate of 600 gpm. Wash water from the tray recycle system is sprayed intermittently against the bottom of this tray to prevent fly ash accumulation and to provide make-up water to the venturi recycle loop.

The venturi throats are fabricated of Incoloy 825 and the balance of the system is constructed of rubber-lined mild steel. The demisters are fabricated from 316L stainless steel.

Pressure drops through the various system components are shown in Table 3.1.

Table 3.1 TYPICAL PRESSURE DROP ACROSS FGD COMPONENTS

Equipment	Pressure drop, inches of water
Venturi	15
Perforated Tray	3
Demister	0.5
Ductwork	1.5
TOTAL	20

3.3 INSTALLATION SCHEDULE

A request for bids for design and installation of an FGD system was issued by NPC in mid-1971, and a contract was awarded to CEA in late 1971. A pilot plant was built and operated in early 1972 and detailed engineering and design were completed during that year. Construction started on both modules in December 1972. The systems were started in early 1974 and were in operation by March and April of that year.

3.4 COST DATA

Detailed cost breakdowns are not available. The two scrubbing systems along with all raw material handling and pond equipment cost $11,000,000 or $50/KW (net). Operating costs have not yet been tabulated due to limited operation.

4.0 FGD SYSTEM PERFORMANCE

Since start-up in early 1974, both modules at the Reid Gardner Station have performed satisfactorily. However, because of difficulties in obtaining a sufficient quantity of trona, the operation of the modules has been subjected to frequent interruptions. The FGD system has periodically been bypassed to conserve trona. As of August 1, 1975, Module 1 had operated for 3814 hours and Module 2 had operated for 2947 hours.

4.1 FGD PROBLEMS AND SOLUTIONS

As noted above, the major problem in the continuous operation of the FGD modules has been the lack of an adequate supply of trona. In order to solve this problem, various alternate sources of sodium carbonate have been used and the present absorbent supply is made up of numerous small supplies.

The system had the usual start-up problems such as rubber liners on recirculation lines becoming loose due to poor fabrication, freeze-up of instruments and plugging of control valve bypass lines. Another minor problem included excessive leakage in the recirculation pumps' seals. Also mechanical failure problems were experienced with the

guillotine dampers, which were later resolved with redesigned drive train components.

An intensive evaluation of problems is not possible due to the fairly brief operating period. However, the simplicity inherent in an open-loop soluble system will naturally minimize operating difficulties. The overall water loop for the plant is closed now that the scrubbers are operational. The scrubber evaporation has reduced the net amount of water going to the evaporation ponds as cooling tower blowdown so that the evaporation pond level is now stable and no water is running out of the pond into any other groundwater systems.

APPENDIX A

PLANT SURVEY FORM

PLANT SURVEY FORM[a]

NON-REGENERABLE FGD PROCESSES

A. COMPANY AND PLANT INFORMATION

1. COMPANY NAME: Nevada Power Company
2. MAIN OFFICE: P.O. Box 230, Las Vegas, Nevada 89151
3. PLANT MANAGER: A.T. (Al) Perry
4. PLANT NAME: Reid Gardner Station
5. PLANT LOCATION: Moapa, Nevada 89025
6. PERSON TO CONTACT FOR FURTHER INFORMATION: D.G. (Dave) Barneby
7. POSITION: Production Mechanical Engr.
8. TELEPHONE NUMBER: (702) 385-5631
9. DATE INFORMATION GATHERED: Form Completed Sept.23,1974
10. PARTICIPANTS IN MEETING

	AFFILIATION
Dave Barneby	
Terry Levitt	Nevada Power
W. H. Ponder	U.S. EPA
John Busik	U.S. EPA
R.W. Gerstle	PEDCo
F.K. Zada	PEDCo

[a] These data were obtained from Nevada Power Co. on September 23, 1974. Some of the data have been updated in the text of the report.

B. PLANT DATA. (APPLIES TO ALL BOILERS AT THE PLANT).

	BOILER NO.				
	1	2			
CAPACITY, MW	120	120			
SERVICE (BASE, PEAK)	Base	Base			
FGD SYSTEM USED	Throw Away Sodium Carbonate				

C. BOILER DATA. COMPLETE SECTIONS (C) THROUGH (R) FOR EACH BOILER HAVING AN FGD SYSTEM.

1. BOILER IDENTIFICATION NO. Reid Gardner No. 1
2. MAXIMUM CONTINUOUS HEAT INPUT 1158 MM BTU/HR
3. MAXIMUM CONTINUOUS GENERATING CAPACITY 126 MW (Gross)
4. MAXIMUM CONTINUOUS FLUE GAS RATE, 473,000 ACFM @ 350 °F
5. BOILER MANUFACTURER Foster Wheeler
6. YEAR BOILER PLACED IN SERVICE 1965
7. BOILER SERVICE (BASE LOAD, PEAK, ETC.) Base Load
8. STACK HEIGHT 200
9. BOILER OPERATION HOURS/YEAR (1973) 7032:06
10. BOILER CAPACITY FACTOR * 73%
11. RATIO OF FLY ASH/BOTTOM ASH ~ 80/20

* DEFINED AS: $\frac{\text{KwH GENERATED IN YEAR}}{\text{MAX. CONT. GENERATED CAPACITY IN KW x 8760 HR/YR}}$

D. FUEL DATA

1. COAL ANALYSIS (as received)

	MAX.	MIN.	AVG.
GHV (BTU/LB.)	12,900	12,000	12,500
S %	0.7	0.4	0.55
ASH %	12	6	9

2. FUEL OIL ANALYSIS (exclude start-up fuel)

GRADE			
S %			
ASH %			

E. ATMOSPHERIC EMISSIONS

1. APPLICABLE EMISSION REGULATIONS

	PARTICULATES	SO_2
a) CURRENT REQUIREMENTS		
AQCR PRIORITY CLASSIFICATION		
REGULATION & SECTION NO.	Clark County	Clark County
MAX. ALLOWABLE EMISSIONS LBS/MM BTU	Less than Ring. 1 0.12	0.15
b) FUTURE REQUIREMENTS, COMPLIANCE DATE	New Plants	New Plants
REGULATION & SECTION NO.	Clark County	Clark County
MAXIMUM ALLOWABLE EMISSIONS LBS/MM BTU	Ringleman 0	0.15

2. PLANT PROGRAM FOR PARTICULATES COMPLIANCE Completed

3. PLANT PROGRAM FOR SO_2 COMPLIANCE Completed

F. PARTICULATE REMOVAL

1. TYPE	MECH.	E.S.P.	FGD
MANUFACTURER	Research Co.		Comb. Equip. Assoc.
EFFICIENCY: DESIGN/ACTUAL	88/75		
MAX. EMISSION RATE* LB/HR			
GR/SCFD	.7940		0.0197
LB/MMBTU			0.055

DESIGN BASIS, SULFUR CONTENT 1.0%

G. DESULFURIZATION SYSTEM DATA

1. PROCESS NAME: Throw away sodium carbonate
2. LICENSOR/DESIGNER NAME: Combustion Equipment Associates
   ADDRESS: 555 Madison Ave., N.Y., N.Y.
   PERSON TO CONTACT: R. S. Sommer
   TELEPHONE NO.: (212) 980-3700
3. ARCHITECTURAL/ENGINEERS, NAME: Bechtel Power Corp.
   ADDRESS: Norwalk, California
   PERSON TO CONTACT: D.C. Philp
   TELEPHONE NO.: (213) 923-9761 Ext. 284
4. PROJECT CONSTRUCTION SCHEDULE:

	DATE
a) DATE OF PREPARATION OF BIDS SPECS.	1971
b) DATE OF REQUEST FOR BIDS	1971
c) DATE OF CONTRACT AWARD	1971
d) DATE ON SITE CONSTRUCTION BEGAN	Dec. 1972
e) DATE ON SITE CONSTRUCTION COMPLETED	1974
f) DATE OF INITIAL STARTUP	April 1974
g) DATE OF COMPLETION OF SHAKEDOWN	1974

*At Max. Continuous Capacity

5. LIST MAJOR DELAYS IN CONSTRUCTION SCHEDULE AND CAUSES:

Design changes

Additional pilot plant testing

Material delivery

Design errors

Labor disputes

Subcontractor delays

6. NUMBER OF SO_2 SCRUBBER TRAINS USED 1

7. DESIGN THROUGHPUT PER TRAIN, ACFM @ 350°F 473,000

8. DRAWINGS: 1) PROCESS FLOW DIAGRAM AND MATERIAL BALANCE

2) EQUIPMENT LAYOUT

H. SO_2 SCRUBBING AGENT

1.	TYPE	Pure or Impure Sodium Carbonate
2.	SOURCES OF SUPPLY	Morrison & Weatherly
3.	CHEMICAL COMPOSITION (for each source)	Kerr McGee Chem., FMC Corp., Stauffer Chem.
	SILICATES	Max. 10% sand
	SILICA	Max. 10% sand
	CALCIUM CARBONATE	NA
	MAGNESIUM CARBONATE	NA
4.	EXCESS SCRUBBING AGENT USED ABOVE STOICHIOMETRIC REQUIREMENTS	0
5.	MAKE-UP WATER POINT OF ADDITION	Tray
6.	MAKE-UP ALKALI POINT OF ADDITION	Venturi

J. SCRUBBER TRAIN SPECIFICATIONS

1. SCRUBBER NO. 1 (a)

TYPE (TOWER/VENTURI) Venturi

LIQUID/GAS RATIO, G/MCF @ 350°F 10

GAS VELOCITY THROUGH SCRUBBER, FT/SEC (15" ΔP)

MATERIAL OF CONSTRUCTION Incolloy 825

TYPE OF LINING Rubber (Tri-Flex) Bottom

INTERNALS:

TYPE (FLOATING BED, MARBLE BED, ETC.) NA

NUMBER OF STAGES NA

TYPE AND SIZE OF PACKING MATERIAL NA

PACKING THICKNESS PER STAGE (b)

MATERIAL OF CONSTRUCTION, PACKING: NA

SUPPORTS:

2. SCRUBBER NO. 2 (a)

TYPE (TOWER/VENTURI)

LIQUID/GAS RATIO, G/MCF @ °F

GAS VELOCITY THROUGH SCRUBBER, FT/SEC

MATERIAL OF CONSTRUCTION

TYPE OF LINING

INTERNALS:

TYPE (FLOATING BED, MARBLE BED, ETC.)

NUMBER OF STAGES

TYPE AND SIZE OF PACKING MATERIAL

a) Scrubber No. 1 is the scrubber that the flue gases first enter. Scrubber 2 (if applicable) follows Scrubber No. 1.

b) For floating bed, packing thickness at rest.

PACKING THICKNESS PER STAGE[b] _____

MATERIAL OF CONSTRUCTION, PACKING: _____

SUPPORTS: _____

3. CLEAR WATER TRAY (AT TOP OF SCRUBBER)

TYPE	Sieve - 3/8" holes
L/G RATIO	1 gal/1000 acfm @ 350°F
SOURCE OF WATER	Ash pond

4. DEMISTER

TYPE (CHEVRON, ETC.)	Radial vane
NUMBER OF PASSES (STAGES)	1
SPACE BETWEEN VANES	~4"
ANGLE OF VANES	Air foil
TOTAL DEPTH OF DEMISTER	~6"
DIAMETER OF DEMISTER	30'
DISTANCE BETWEEN TOP OF PACKING AND BOTTOM OF DEMISTER	NA
POSITION (HORIZONTAL, VERTICAL)	Horizontal
MATERIAL OF CONSTRUCTION	SS 316L
METHOD OF CLEANING	None
SOURCE OF WATER AND PRESSURE	None
FLOW RATE DURING CLEANINGS, GPM	None
FREQUENCY AND DURATION OF CLEANING	None

REMARKS 3 concentric rings of vanes w/gutter collectors at outer edges.

5. REHEATER

TYPE (DIRECT, INDIRECT) Indirect

b) For floating bed, packing thickness at rest.

DUTY, MMBTU/HR _____

HEAT TRANSFER SURFACE AREA SQ.FT _____

TEMPERATURE OF GAS: IN _____ OUT +50°F @ 32° ambient

HEATING MEDIUM SOURCE Boiler Secondary Superheater

TEMPERATURE & PRESSURE _____

FLOW RATE _____ LB/HR

REHEATER TUBES, TYPE AND MATERIAL OF CONSTRUCTION Aerofin - Extended Surf.

REHEATER LOCATION WITH RESPECT TO DEMISTER Following

METHOD OF CLEANING None

FREQUENCY AND DURATION OF CLEANING None

FLOW RATE OF CLEANING MEDIUM None LB/HR

REMARKS _____

6. SCRUBBER TRAIN PRESSURE DROP DATA

	INCHES OF WATER
PARTICULATE SCRUBBER	
SO_2 SCRUBBER	+15
CLEAR WATER TRAY	+3
DEMISTER	+.5
REHEATER	Nil
DUCTWORK	+1.5
TOTAL FGD SYSTEM	+20

7. FRESH WATER MAKE UP FLOW RATES AND POINTS OF ADDITION

TO: DEMISTER None

QUENCH CHAMBER None

ALKALI SLURRYING ~20 gpm avg. 53 gpm max.

PUMP SEALS ~ 6 gpm

OTHER Wash tray 135 gpm

TOTAL max. 190 gpm per unit

FRESH WATER ADDED PER MOLE OF SULFUR REMOVED NA

8. BYPASS SYSTEM

CAN FLUE GAS BE BYPASSED AROUND FGD SYSTEMS Yes, @ 100% load

GAS LEAKAGE THROUGH BYPASS VALVE, ACFM Negligible

K. SLURRY DATA

	pH	% Solids	Capacity (gal)	Hold up time
LIME/LIMESTONE SLURRY MAKEUP TANK				
PARTICULATE SCRUBBER EFFLUENT HOLD TANK (a)				
SO_2 SCRUBBER EFFLUENT HOLD TANK (a)				

L. LIMESTONE MILLING AND CALCINING FACILITIES: INDICATE BOILERS SERVED BY THIS SYSTEM.

TYPE OF MILL (WET CYCLONE, ETC.) _____

NUMBER OF MILLS _____

CAPACITY PER MILL _____ T/HR

RAW MATERIAL MESH SIZE _____

PRODUCT MESH SIZE _____

SLURRY CONCENTRATION IN MILL _____

CALCINING AND/OR SLAKING FACILITIES Mixing tank

SOURCE OF WATER FOR SLURRY MAKE UP OR SLAKING TANK Ash pond

M. DISPOSAL OF SPENT LIQUOR

1. SCHEMATICS OF SLUDGE & FLY ASH DISPOSAL METHOD

(IDENTIFY QUANTITIES OR SCHEMATIC) _____

2. CLARIFIERS (THICKENERS)

NUMBER 2 clarifying ponds

DIMENSIONS 6 acres, 8 acres

CONCENTRATION OF SOLIDS IN UNDERFLOW NA

3. ROTARY VACUUM FILTER

NUMBER OF FILTERS _____

CLOTH AREA/FILTER _____

CAPACITY _____ TON/HR (WET CAKE)

CONCENTRATION OF SOLIDS IN CAKE _____

PRECOAT (TYPE, QUANTITY, THICKNESS) _____

REMARKS _____

_____

_____

4. SLUDGE FIXATION

POINT OF ADDITIVES INJECTION None

FIXATION MATERIAL COMPOSITION _____

FIXATION PROCESS (NAME) _____

FIXATION MATERIAL REQUIREMENT/TONS OF DRY SOLIDS OF SLUDGE

_____

ESTIMATED POND LIFE, YRS. _____

CONCENTRATION OF SOLIDS IN FIXED SLUDGE _____

METHOD OF DISPOSAL OF FIXED SLUDGE _____

INITIAL SOLIDIFICATION TIME OF FIXED SLUDGE _____

5. SLUDGE QUANTITY DATA

POND/LANDFILL SIZE REQUIREMENTS, ACRE-FT/YR _____

IS POND/LANDFILL ON OR OFFSITE On-site

TYPE OF LINER Natural clay

IF OFFSITE, DISTANCE AND COST OF TRANSPORT _____

POND/LANDFILL DIMENSIONS AREA IN ACRES 45-acre evaporation pond
DEPTH IN FEET _____

DISPOSAL PLANS; SHORT AND LONG TERM _____

N. COST DATA

1. TOTAL INSTALLED CAPITAL COST $11,000,000

2. ANNUALIZED OPERATING COST _____

3. COST BREAKDOWN

	COST ELEMENTS	INCLUDED IN ABOVE COST ESTIMATE		ESTIMATED AMOUNT OR % OF TOTAL INSTALLED CAPITAL COST
		YES	NO	
A.	CAPITAL COSTS			
	SO_2 SCRUBBER TRAINS	☐	☐	
	LIMESTONE MILLING FACILITIES	☐	☐	
	SLUDGE TREATMENT & DISPOSAL POND	☐	☐	
	SITE IMPROVEMENTS	☐	☐	
	LAND, ROADS, TRACKS, SUBSTATION	☐	☐	
	ENGINEERING COSTS	☐	☐	
	CONTRACTORS FEE	☐	☐	
	INTEREST ON CAPITAL DURING CONSTRUCTION	☐	☐	
B.	ANNUALIZED OPERATING COST			
	FIXED COSTS			
	INTEREST ON CAPITAL	☐	☐	
	DEPRECIATION	☐	☐	
	INSURANCE & TAXES	☐	☐	
	LABOR COST INCLUDING OVERHEAD	☐	☐	
	VARIABLE COSTS			
	RAW MATERIAL	☐	☐	
	UTILITIES	☐	☐	
	MAINTENANCE	☐	☐	

4. COST FACTORS

a. ELECTRICITY _____

b. WATER _____

c. STEAM (OR FUEL FOR REHEATING) _____

d. FIXATION COST _____ $/TON OF DRY SLUDGE

e. RAW MATERIAL PURCHASING COST _____ $/TON OF DRY SLUDGE

f. LABOR: SUPERVISOR _____ HOURS/WEEK _____ WAGE

OPERATOR _____ _____

OPERATOR HELPER _____ _____

MAINTENANCE _____ _____

O. MAJOR PROBLEM AREAS: (CORROSION, PLUGGING, ETC.)

1. SO_2 SCRUBBER, CIRCULATION TANK AND PUMPS.

a. PROBLEM/SOLUTION _____

_____

_____

_____

_____

_____

_____

2. DEMISTER

PROBLEM/SOLUTION _____

_____

_____

_____

_____

_____

3. REHEATER

PROBLEM/SOLUTION _____

_____

_____

_____

_____

_____

4. VENTURI SCRUBBER, CIRCULATION TANKS AND PUMPS

PROBLEM/SOLUTION_____

5. I.D. BOOSTER FAN AND DUCT WORK

PROBLEM/SOLUTION_____

6. LIMESTONE MILLING SYSTEM OR LIME SLAKING

PROBLEM/SOLUTION_____

7. SLUDGE TREATMENT AND DISPOSAL

PROBLEM/SOLUTION_____

8. MISCELLANEOUS AREA INCLUDING BYPASS SYSTEM

PROBLEM/SOLUTION

P. DESCRIBE FACTORS WHICH MAY NOT MAKE THIS A REPRESENTATIVE INSTALLATION

Q. DESCRIBE METHODS OF SCRUBBER CONTROL UNDER FLUCTUATING LOAD. IDENTIFY PROBLEMS WITH THIS METHOD AND SOLUTIONS. IDENTIFY METHOD OF pH CONTROL AND LOCATION OF pH PROBES.

R. COMPUTATION OF FGD SYSTEM AVAILABILITY FACTOR

BOILER RATING OR MAXIMUM CONTINUOUS CAPACITY, MW _____

PERIOD MONTH/YEAR	FLUE GAS DESULFURIZATION MODULES							
	MODULE A		MODULE B		MODULE C		MODULE D	
	DOWN DUE TO		DOWN DUE TO		DOWN DUE TO		DOWN DUE TO	
	BOILER (HRS)	MODULE (HRS)	BOILER (HRS)	MODULE (HRS)	BOILER (HRS)	MODULE (HRS)	BOILER (HRS)	MODULE (HRS)

Availability factor computation:

1. Divide boiler capacity by the number of modules and obtain MW/module = χ
2. Multiply boiler capacity by number of hours during period = a
3. Add all down times due to module trouble for all modules during period = b
4. Add all down times due to boiler trouble or reduction in electricity demand for all modules during period = c
5. Availability factor = $\frac{[a - \chi\ (b + c)]100}{a - \chi\ c}$ = %

5/17/74

APPENDIX B

PLANT PHOTOGRAPHS

Photo No. 1 General view of the Reid Gardner Station of the Nevada Power Company.

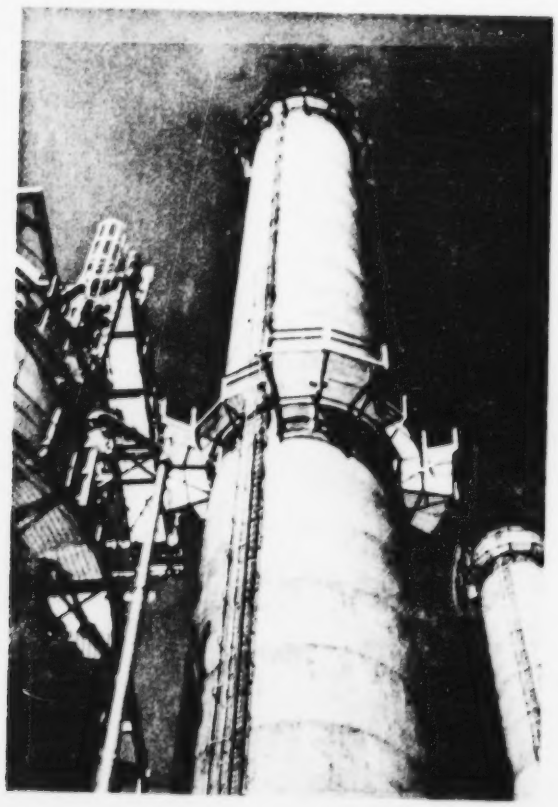

Photo No. 2 Stack plume-scrubber in operation.

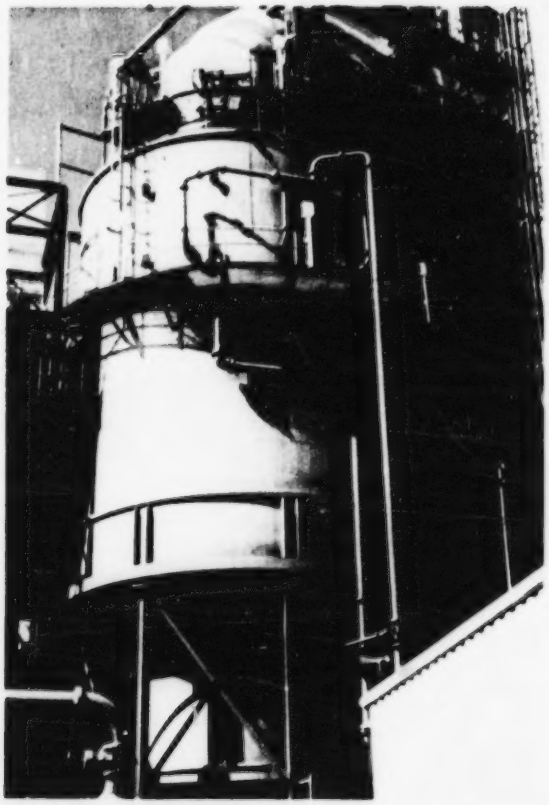

Photo No. 3 Scrubber module and gas outlet duct.

Photo No. 4 Sludge pond and effluent stream.

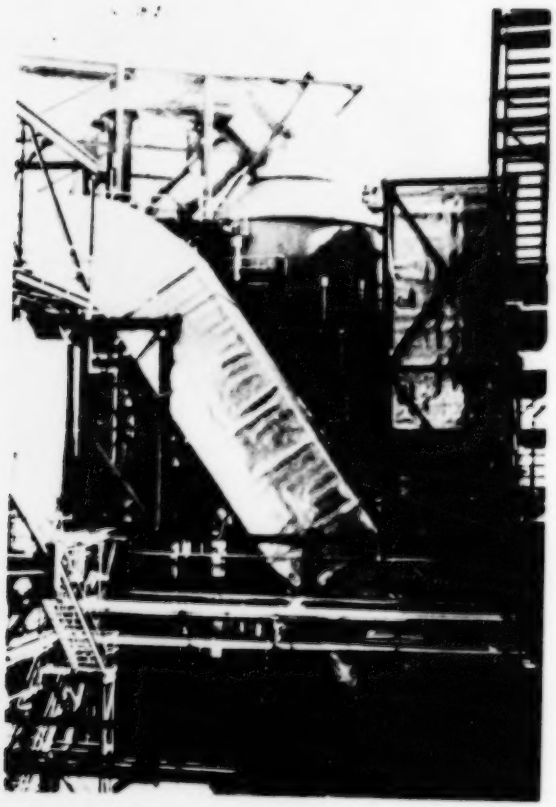

Photo No. 5 Duct after cyclone to I.D. fan. Note hot-air duct into scrubber exhaust stream.